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Indirect impact of COVID-19 on environment: A brief study in Indian context

Snehal Lokhandwala*, Pratibha Gautam

Department of Environmental Science & Technology, Shroff S.R. Rotary Institute of Chemical Technology, Ankleshwar, Gujarat, 393135, India

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ABSTRACT

Worldwide spread of COVID-19 in a quite short time has brought a dramatic decrease in industrial activities, road traffic and tourism. Restricted human interaction with nature during this crisis time has appeared as a blessing for nature and environment. Reports from all over the world are indicating that after the outbreak of COVID-19, environmental conditions including air quality and water quality in rivers are improving and wildlife is blooming. India has always been a hub of pollution with huge population, heavy traffics and polluting industries leading to high air quality index (AQI) values in all major cities. But after declaration of lockdown due to COVID-19, quality of air has started to improve and all other environmental parameters such as water quality in rivers have started giving a positive sign towards restoring. This paper provides evidence-based insight into improvement of air quality and environment during pre and post lockdown of this pandemic situation. An attempt has been made to visualize the improvement in the air quality using tools like satellite images of Indian atmosphere, results of onsite real-time monitoring at specific locations (Ghaziabad-highest polluting city of India) and Air quality index (AQI) calculated by central pollution control board of India.

1. Introduction

Coronaviruses (CoVs) are a group of viruses which affects human beings through zoonotic transmission. This is the third time in past two decades that novel virus has created pandemic condition, after Severe Acute Respiratory Syndrome (SARS) in 2003 and Middle East Respiratory syndrome corona virus (MERS-CoV) in 2012 (Ramdan and Shaib, 2019; Zhong et al., 2003). Pertaining to the Corona virus (2019), it was on December 31, 2019 wherein first case was reported to WHO Country Office in Wuhan, China with symptoms of unexplained low respiratory infections. This was classified as “pneumonia of unknown etiology” as the cause of infection was not known. On January 12, 2020, WHO found that Corona virus was the reason of this infection in Wuhan and later on 11th February, WHO Director-General announced this novel CoV as ‘COVID-19’ which is an acronym of ‘Corona virus disease 2019’ (Cascella et al., 2020). Covid-19 contain a single-stranded RNA as nuclei material and are 65 nm - 125 nm in diameter (Shereen et al., 2020). The major causes of concern for Covid-19 includes its global scale transmission, repeated emergence, significant number of deaths, infection and mortality to care providers and multiplicative effect in vulnerable or susceptible groups.

Covid-19 was declared pandemic disease by Director General-WHO on 11th March, he also briefed regarding the 13-fold increase in positive cases in China and 114 countries suffering from 1, 18,000 positive

cases and 4291 deaths till date (World Health Organization, 2020). In India the first confirmed positive case was reported on 30th January in a student from Thrissur district of Kerala who had returned home for a vacation from Wuhan University in China (India Today, 2020a) followed by two other cases on February 2 and 3 again in Kerala having the same history. As on 14th April, Ministry of Health & Family Welfare (MOHFW) reported 10,815 positive cases and 358 deaths covering 32 states in India. Fig. 1 shows the spread of COVID-19 from January 30, 2020 to April 14, 2020. It is evident from the figure that spread of corona virus became rapid after 15 March and started taking a horrible shape in entire country.

Presently in comparison to the top six affected countries viz USA, Italy, Spain, China, Germany and Iran, we in India have lesser capacity to serve patients. With a population of 1.2 billion, India has only 118 Government approved testing laboratories, 1.1363 beds per thousand patients (China has 4.2) and more than one million tests done. On the contrary, India has the highest recovery rate of 41.39% as compared to Italy (16.91%) and USA (3.17%) which is the direct effect of lockdown. Although, the researchers round the globe are rigorously working to find the cure of the infection caused by this deadly virus but unfortunately, till date no definite cure or vaccine has got developed. The only way to control the spread of this virus at this moment is suggested to be “social distancing”, which is being practiced by many countries at this crisis time and has led to reduction GHG emissions in air

* Corresponding author.

E-mail address: snehal.lokhandwala@sriict.in (S. Lokhandwala).

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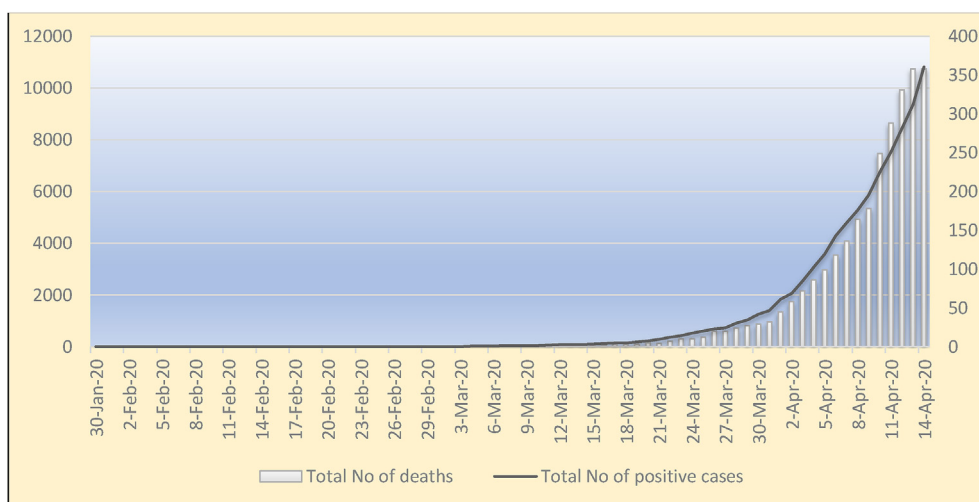


Fig. 1. Covid 19 in India from Jan 30, 2020 to April 14, 2020 (MOHFW-GOI, 2020).

(Zambrano-Monserrate et al., 2020) at global level.

During past two decades, India has witnessed an expeditious industrial growth which has certainly improved the standard of living of its people and it is also evident from the rising vehicular fleet on roads. But we have paid a heavy cost for this development in terms of poisoning the air we breathe. As per press release of World Health Organization (2nd May 2018), around 7 million people die every year from exposure to fine particles in polluted air (World Health Organization, 2018). State of India's Environment (SoE) report, 2019 have declared that 12.5% of all deaths in India are due to Air Pollution (India Today, 2020b). The environment in India was extremely degraded and all the pollutant levels and Air quality index left the limits way behind. Observing the increasing rate of corona cases in India and subsequent looming crisis, honourable prime minister of India, Shri Narendra Modi on March 24, 2020 declared a complete lockdown of 21 days for entire country during his live address to the nation, which was further extended for 19 days on April 14, 2020 in II phase followed by 14 days till 17th May in III phase and more 14 days in Phase IV. Various restrictions posed by GOI and subsequent lockdown, anthropogenic activities like industrial projects, vehicular movement, construction projects, tourism other common transportation activities witnessed a 'never before' stagnant phase. In India, apart from taking necessary administrative measures such as restriction on social gathering events, travel restrictions, containment of corona suspects and their treatment, Government of India (GOI) has directed the citizens to maintain adequate social distancing and to use personal protective equipment like masks. However, the COVID-19 has created a catastrophic situation for all and it would have adverse effect on Indian economy too (The Economic Times, 2020), there is positive side of the coin also which may alleviate the woeful facts of COVID-19. As many of the countries are observing self-quarantine and social distancing for a more than two months now, it has given the nature a "healing time" with reduced human interference in natural environment. Major impact of lockdown due to COVID-19 can be observed on air quality, which is being experienced by everyone and recorded in various official reports. Smog has given way to blue skies in cities like Delhi, marine life is seeing increased activity, pollution levels have dropped in almost all the metro cities and animals as well as birds are moving around on their own accord. It was also observed that in metro cities like Delhi, as the energy foot print was high, the lockdown has improved the air quality at higher scale (Mahato et al., 2020). Mandal and Pal (2020) in their studies on air quality of the four selected stone crushing clusters at Dwarka river basin of Eastern India noticed reduction of PM_{10} concentration from 189–278 $\mu g/m^3$ to 50–60 $\mu g/m^3$ after 18 days of commencement of lockdown. Analysis using WRF-AERMOD modelling system on actual

and unfavourable meteorology revealed that even the predicted $PM_{2.5}$ increases in India due to unfavourable meteorology, the average concentration would still be under CPCB limits (Sharma et al., 2020). Although the pandemic situation is out of control for human beings but the positive side of it has made us to reconsider our lives and reorganize it in a way that has less impact on our planet. The situation today is a "reset" for nature and mankind, giving us a prospect to observe and analyse in and around.

The impact of air pollution on Indian population and their health was extensively studied in past by several researchers. The Urban air quality management strategies were planned which concentrated on emission inventory, control strategies, monitoring network and participation of public (Gulia et al., 2015). A general comparison between the major air pollutants was also studied and the impact of industrialization, transportation and other anthropogenic activities were analysed (Singh et al., 2007). In this paper information from several government and non-government agencies have been collected and analysed to understand the change in quality of various environmental factors such as air and water quality due to lockdown caused by Covid-19. Different tools like satellite images and Air Quality index (AQI) have been used to study the indirect effect of COVID-19 in Indian context. Outcomes of the study will help the policy makers to define the Post-Covid strategy for the country, as the pollution level which we were not able to achieve during last decade (even after applying all sort of technological advancement) have become a real thing due to lockdown. This study can also be used as a baseline study to analyse the health impact (specifically on sensitive receptors) due to reduction in air pollution.

2. Impact on air quality

2.1. Case study of Ghaziabad city

2.1.1. Study area

Ghaziabad is the biggest city of Western Uttar Pradesh, second largest industrial city of Uttar Pradesh and it's a part of National Capital Region. It has more or less the same environmental conditions as that of Delhi (National Capital). The 2011 Census data shows that Ghaziabad has urban agglomeration with population of 46.82 lacs indicating a decadal growth rate of 29.7% and density of 3971 individuals/ km^2 . District Ghaziabad lies between geo-coordinates 28° 40' 12" N and 77°25'12" E with geographical area of 777.9 sq. km with rectangular dimensions. The city has adverse pollution problems mainly due to traffic congestion and dust. In a recently release IQAir 2019 World Air Quality report, it is found that out of 20 world's most polluted cities, 14

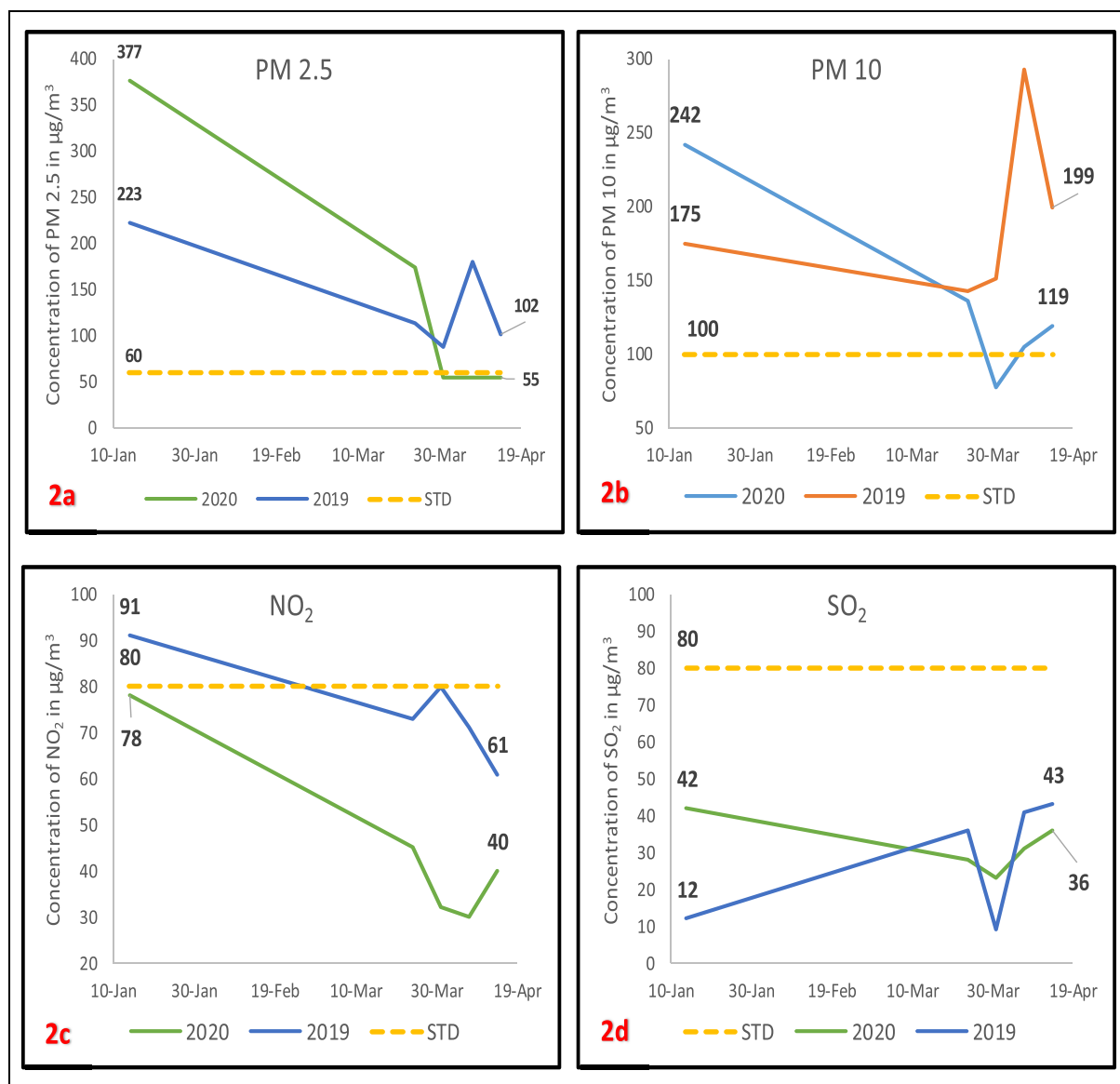


Fig. 2. Trends for pollutant concentration for Ghaziabad City (NAQI-CPCB, 2020).

are from India and Ghaziabad is in first place with PM_{2.5} pollution level of 110.2 µg/m³ in 2019 compared to the permissible limit of 60 µg/m³ (for 24 h) (IQAir report, 2019). This indicates severe degree of air pollution which could not be controlled by state and central government even after several efforts. Therefore, Ghaziabad was selected as the study area and the things changed there in early 2020 when Government of India (GOI) declared a complete lockdown in country in order to prevent community transmission of corona virus. Similar steps were also taken in various part of world which negatively influenced the economy of those countries but had a positive impact on overall air quality (World Economic Forum, 2020).

2.1.2. Environmental impact of lockdown period on Ghaziabad district

In order to study the environmental impact of lockdown on the air quality of Ghaziabad District, 24 h average concentrations of four major pollutants of specific dates were compared to the concentration data of previous year and the results are compiled in Fig. 2a–d. Where Fig. 2a–d corresponds to the trends for PM_{2.5}, PM₁₀, Nitrogen dioxide (NO₂) and Sulphur dioxide (SO₂) respectively. Dates were randomly selected representing different weeks of different month where, initial three dates (10 January, 30 January and 19 February) show ‘before lockdown’

condition, fourth date (10 March) represents dates where social distancing was partially and voluntarily followed and last two dates (30 March and 19 April) represent strict lockdown condition during year 2020, whereas same date were selected from year 2019 also to make a comparison with previous year pattern.

The pollutant concentration for selected parameters on selected dates were taken from Loni Ghaziabad, Air quality monitoring station governed by Central Pollution Control Board, and the results summarised in Fig. 2 clearly indicates that due to lockdown of human activities including transportation and industries in Ghaziabad, the pollutant levels dropped down significantly. Concentration of these four pollutants on 14th April 2020 (last day of first lockdown) were also compared to the concentrations on 14th January 2020 (air quality, 3 months back) and 14th April 2019 to assess the percent reduction in pollutant concentration and the results are quite favourable. Table 1 shows the percentage reduction in the concentration of four major pollutants due to lockdown (indirectly due to COVID-19) which indicates that up to 85% reduction in PM_{2.5} concentration was observed in one of the most polluted cities of India.

Table 1

% Reduction in concentration of four major pollutants at Ghaziabad (NAQI-CPCB, 2020).

Parameter	% Reduction as compared to Jan 14, 2020 (Before 3 months)	% Reduction as compared to April 14, 2019 (Before 1 yr)
PM _{2.5}	85.1	46.1
PM ₁₀	50.8	40.2
NO ₂	48.7	34.4
SO ₂	14.3	16.3

Table 2a

Analysis of variance for PM_{2.5}.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	158461.664	3	52820.555	16.815	.000
Within Groups	75392.356	24	3141.348		
Total	233854.020	27			

2.1.3. Statistical analysis

In order to investigate the effect of lockdown on air quality statistically, daily average data of first week of the month was analysed for four consecutive months (January'20, February'20, March'20 and April'20), in which first three months show normal situation (no lockdown) whereas April month shows the lockdown situation. To arrive convincing conclusion on "effect of lockdown on pollutant concentration", one-way ANOVA test was performed to analyse the data, with a hypothesis that mean pollutant concentration has no effect of lockdown. The result of ANOVA for different parameters including PM_{2.5}, PM₁₀, SO₂, NO₂, O₃, NO, NH₃, CO, Benzene are summarised in Tables 2a–i.

ANOVA results show that only for SO₂, the p value is > 0.05, which lead to acceptance of hypothesis that lockdown has no impact on SO₂ concentration or air quality. The reason behind this may be that there are two major activities which leads to existing concentration of SO₂: first, the vehicular activities, stopping of which is not having much impact on SO₂ concentration because in NCR region already Bharat VI is implemented which does not allow much SO₂ emission from vehicular exhaust and therefore, restriction on vehicular activities does not make much impact on SO₂ concentration. Other sources of SO₂ are industrial activities which were continued during lockdown. For all other parameters the p value < 0.05, leading to rejection of null hypothesis implying that lockdown had significant impact on concentration of most of the parameters including PM_{2.5}, PM₁₀, NO₂, NO, O₃, NH₃, CO and Benzene.

The correlations between the above pollutant concentrations at Ghaziabad during the four weeks i.e. two before and two during lockdown are shown in Table 3. The average concentrations of PM_{2.5} is highly correlated with NO₂ (r = 0.93), NO (r = 0.84), NH₃ (r = 0.91) and Benzene (r = 0.90). Similarly, PM₁₀ has also high correlations with all other pollutants except SO₂. The results imply that control of local transportation and limited industrial activities has decreased the overall pollution load on air. SO₂ has no major correlation with other pollutants which depicts no major decrease in its concentration. All other pollutants have moderate to high correlations with each other.

Table 2b

Analysis of variance for PM₁₀.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	195302.906	3	65100.969	10.807	.000
Within Groups	144580.127	24	6024.172		
Total	339883.033	27			

Table 2c

Analysis of variance for SO₂.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	42.722	3	14.241	.806	.503
Within Groups	423.839	24	17.660		
Total	466.560	27			

Table 2d

Analysis of variance for NO₂.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5903.236	3	1967.745	19.086	.000
Within Groups	2474.322	24	103.097		
Total	8377.559	27			

Table 2e

Analysis of variance for NO.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4476.535	3	1492.178	8.923	.000
Within Groups	4013.311	24	167.221		
Total	8489.846	27			

Table 2f

Analysis of variance for O₃.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3239.852	3	1079.951	8.756	.000
Within Groups	2960.165	24	123.340		
Total	6200.017	27			

Table 2g

Analysis of variance for NH₃.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8404.867	3	2801.622	34.042	.000
Within Groups	1975.173	24	82.299		
Total	10380.040	27			

Table 2h

Analysis of variance for CO.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.590	3	1.530	9.628	.000
Within Groups	3.813	24	.159		
Total	8.403	27			

Table 2i

Analysis of variance for Benzene.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.782	3	2.927	9.056	.000
Within Groups	7.758	24	.323		
Total	16.541	27			

2.2. Study of air quality improvement using satellite images

Aerosols adversely affect human health by degrading the air quality which results to premature mortality through lung cancers and cardiopulmonary diseases (Partanen et al., 2018). MODIS (Moderate Resolution Imaging Spectroradiometer) aboarded Terra and Aqua satellites (Sentinel-5P and AURA) from NASA creates satellite images of optical depth and size distribution of ambient aerosol over the globe on

Table 3
Correlation table for atmospheric pollutants at Loni, Ghaziabad District.

Pollutant ↓	→	PM 2.5	PM10	SO ₂	NO ₂	O ₃	NO	NH ₃	CO	C ₆ H ₆
PM 2.5	Pearson coefficient	1	0.95***	0.30	0.93***	−0.56***	0.84***	0.93***	0.91***	0.90***
	P (2 tailed)		0	0.121	0	0.002	0	0	0	0
	N	28	28	28	28	28	28	28	28	28
PM 10	Pearson coefficient	0.95***	1	0.37	0.93***	−0.49***	0.78***	0.90***	0.81***	0.80***
	P (2 tailed)	0		0.05	0	0.008	0	0	0	0
	N	28	28	28	28	28	28	28	28	28
SO ₂	Pearson coefficient	0.30	0.37	1	0.17	0.20	0.24	0.26	0.23	0.27
	P (2 tailed)	0.121	0.05		0.375	0.315	0.223	0.189	0.237	0.171
	N	28	28	28	28	28	28	28	28	28
NO ₂	Pearson coefficient	0.93***	0.93***	0.17	1	−0.62***	0.79***	0.90***	0.84***	0.84***
	P (2 tailed)	0	0	0.375		0	0	0	0	0
	N	28	28	28	28	28	28	28	28	28
O ₃	Pearson coefficient	−0.56***	−0.49***	0.20	−0.62***	1	−0.42***	−0.62***	−0.53***	−0.52***
	P (2 tailed)	0.002	0.008	0.315	0		0.027	0	0.004	0.005
	N	28	28	28	28	28	28	28	28	28
NO	Pearson coefficient	0.84***	0.78***	0.24	0.79***	0.42***	1	0.85***	0.95***	0.91***
	P (2 tailed)	0	0	0.223	0	0.027		0	0	0
	N	28	28	28	28	28	28	28	28	28
NH ₃	Pearson coefficient	0.93***	0.90***	0.26	0.90***	−0.63***	0.85***	1	0.88***	0.85***
	P (2 tailed)	0	0	0.189	0	0	0		0	0
	N	28	28	28	28	28	28	28	28	28
CO	Pearson coefficient	0.91***	0.81***	0.23	0.84***	−0.53***	0.94***	0.85***	1	0.95***
	P (2 tailed)	0	0	0.237	0	0.004	0	0		0
	N	28	28	28	28	28	28	28	28	28
C ₆ H ₆	Pearson coefficient	0.90***	0.80***	0.27	0.84***	0.52***	0.91***	0.85***	0.95***	1
	P (2 tailed)	0	0	0.171	0	0.005	0	0	0	
	N	28	28	28	28	28	28	28	28	28

The correlations are expressed as Person's correlation coefficient, where *** denote significant correlations at $p < 0.01$ (two-tailed).

hourly basis. The Aerosol Optical depth (AOD) measures how light is absorbed or reflected by airborne particles. Hazy conditions show optical depth of 1 or above and optical depth of less than 0.1 over entire atmospheric vertical column is considered 'clean'. Fig. 3 shows the AOD measurements over India during 31 March and 5 April for six years (2016–2020) (NASA, 2020). The yellow pixels and bluish pixels showing little or very low concentration of aerosol in 2020 as compared to dark brown and tan pixels, Fig. 3 clearly indicates the impact of lock down period (restricted human activities) due to Covid-19.

European Space agency also revealed that there is a significant reduction in Nitrogen dioxide (NO₂) levels (generally emitted in the atmosphere through vehicular exhausts, power plants and industries) in Indian atmosphere during of the lockdown (ESA, 2020). The Copernicus Sentinel-5P satellite showed averaged NO₂ concentrations in Indian atmosphere from January 1, 2020 to March 24, 2020 and 25 March 2020 to 20 April 2020 (the first lockdown period) compared to the same time frame last year. Fig. 4 show around 40–50% drop in the NO₂ concentrations across major cities of India (yellow-orange colour shows occurrence of NO₂ in atmosphere).

Particulate matter (PM_{2.5} and PM₁₀) is another indicator of air quality and it originates from various emission sources like industries, power plants, refuse burning and road dust re-suspension etc. As lockdown restricted all these activities in entire country, its direct impact on PM concentration is inevitable. To analyse the same, change in PM concentration was observed through satellite images as shown in Figs. 5 and 6; where Fig. 5 shows satellite images taken on 20th March 2020 and April 12, 2020 for PM 2.5 and Fig. 6 shows the same for PM 10.

The satellite views clearly depict how the concentration of PM_{2.5} and PM₁₀ has reduced during the span of one month especially in the Northern and eastern states including the capital New Delhi (The hot spot of air pollution).

2.3. Studying the impact on air quality using AQI

Effect of COVID-19 on air quality was also studied through Air

Quality index (AQI) which is one of the important tools to measure the level of pollution due to major air pollutants. It is an overall scheme proposed by Central Pollution Control board (CPCB) which transforms the weighted values of seven air pollutants (PM_{2.5}, PM₁₀, CO, NH₃, NO₂, SO₂ and Ozone) in to a single number or set of numbers. It categorises the air quality into six categories from Good (with AQI ranging from 0 to 50) to Severe (with AQI more than 401). To analyse the effect of lockdown caused by COVID-19, AQIs before and during lockdown for 10 Indian states were compared in Table 4.

Data summarised in Table 4 demonstrate that air quality in India has been significantly improved after corona outbreak. New Delhi which was in a very bad shape before one month with frequent occurrence of smog and horribly high AQI around 300–400 shows AQI of 94 which is moderate. It is noteworthy that people from Jalandhar (Punjab) are now able to see the 'Dhauldhara mountain range' of Himachal from approximately 200 km after 30 years (CNN Travel, 2020).

3. Other indirect impacts of Covid-19 pandemic

3.1. Impact on river quality

Articles and reports in dailies and other electronic media reveal the improvement in the quality of number of rivers of India including Ganga, Cauvery, Sutlej and Yamuna etc. The primary cause is lack of industrial effluents entering the rivers due to lockdown situation under this pandemic situation. The DO levels of river Ganga as per reports has gone above 8 ppm and BOD levels down below 3 ppm at Kanpur and Varanasi (SANDRP, 2020) which ranged around 6.5 ppm and 4 ppm in 2019 respectively (Pathak and Mishra, 2020) Many other factors have also contributed in enhancing the quality of the rivers like high snowfall now melting with summer, reduction of irrigation water demand, above average rainfall and also human born factors including reduction of religious and cultural activities like puja, bathing, cremations on the banks of the rivers.

The real time water monitoring data provided by CPCB state that 27 out of 36 monitoring units placed at different places wherein the river

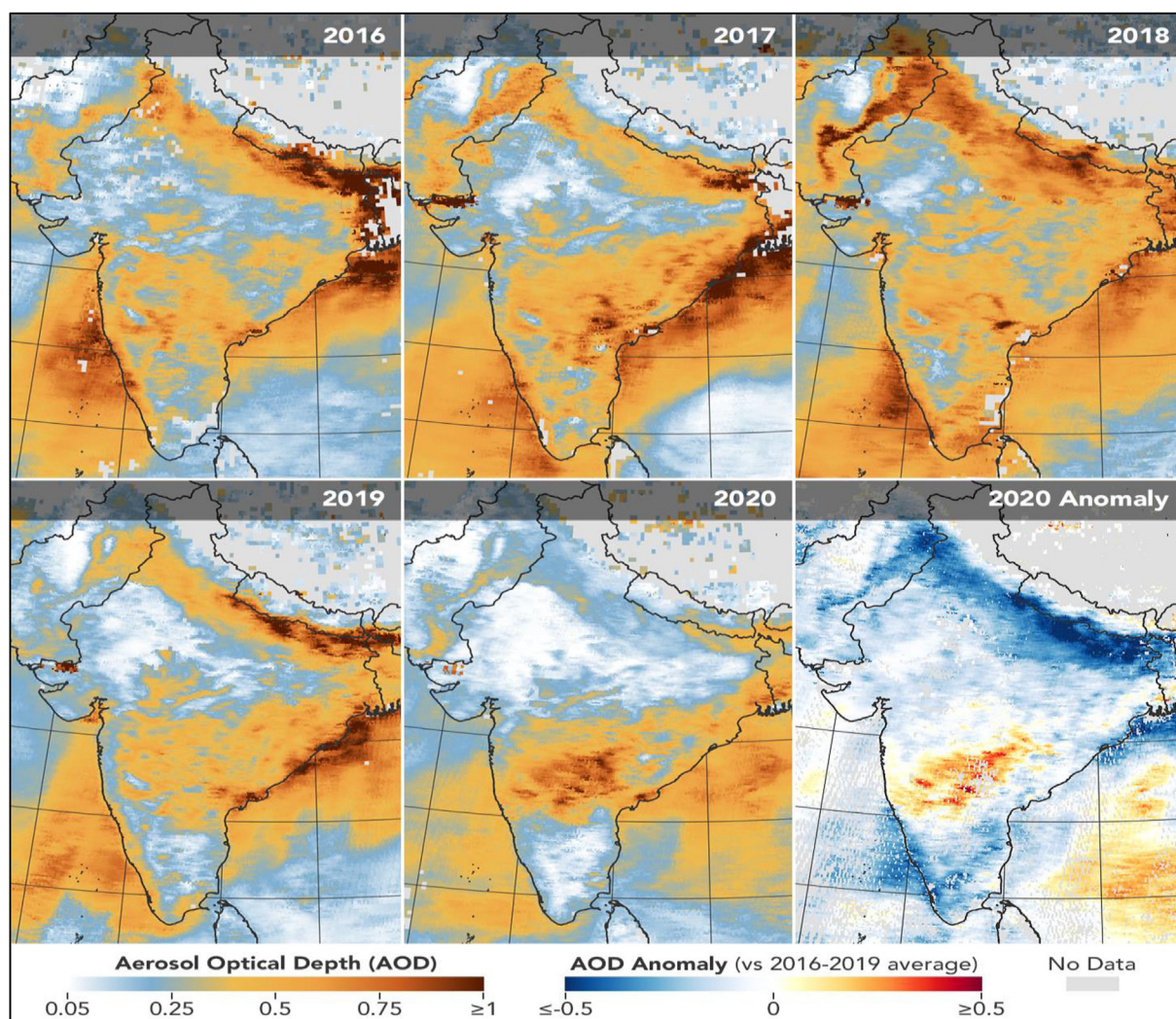


Fig. 3. AOD concentration in India from the period March 31 to April 5 in 2016–2020 (NASA, 2020).

Ganga flows were found suitable for propagation of wildlife and fisheries and bathing (The Tribune, 2020). CPCB also has three real time monitoring stations in Kanpur and Table 5 shows the water quality data as reported through these monitoring stations on 28th March 2020 i.e. during lockdown period.

It is reported that in routine days the total effluent dumped in Ganga is around 6500–6700 MLD and out of which 700 MLD (approximately 10%) come from industries. 30% of total BOD is due to industries situated along the holy river which is 130–150 tons per day. The organic load can be diluted in the river but the industrial pollution destroys the self-cleansing property of water. Researchers believe that the self-cleansing property of river Ganga has improved which has enhanced the water quality by 40–50% during this lockdown (Hindustan Times, 2020a). Scientists have claimed that water quality has remarkably improved at Haridwar Ghats which is up to drinking standards (News18 Buzz, 2020). The Ghats are also closed for people taking holy bath in the water or dumping flowers and other waste in it has stopped. This has resulted in water looking visibly cleaner with aquatic life moving around. Fig. 7 show the clean waters of Ganga at Haridwar.

River Yamuna also in most parts of Delhi is appearing clearer, blue and pristine after years. The toxic foam caused due to mix of detergents, chemicals from industries and sewage has vanished clearly in southeast Delhi's Kalindi Kunj. As per Karnataka State Pollution Control Board, the quality of water in Cauvery and tributaries like Kabini, Hemavati, Shimsha and Lakshmanathirtha is also back to what it used to be

before decades (The Hindu, 2020). The pollution discharge has drastically fallen sharply in Buddha nullah which carries effluents from 2423 industrial units into Sutlej River in Punjab during this lockdown (Hindustan Times, 2020b).

3.2. Reconsider and reflect

As adversity always introduces man to himself, this situation has provided an opportunity to reflect on things and give a better understanding of who we are, what we should do and how would we do. The technologies adopted have certainly changed our mode of working and made us aware of how resilient and capable we are to handle such extreme situations. We are learning to be grateful to life and simple things they we usually ignore in routines. The importance of nature, mother earth and the natural resources have clearly been understood by humans in this pandemic situation. The world will have to face many long term and short terms effects of Covid-19. The patients who had developed Acute Respiratory Distress Syndrome (ARDS) being Corona positive, will be at greater risk of long term health issues related to major organs like heart, lungs etc. People who have recovered from this disease may have post-traumatic stress disorder (PTSD), depression and anxiety. Not only health but this pandemic situation will result in to a demand and supply-side crises which would affect entire business ecosystems and consumer behaviour. Every sector will try to develop buffers to deal with future catastrophic situations.

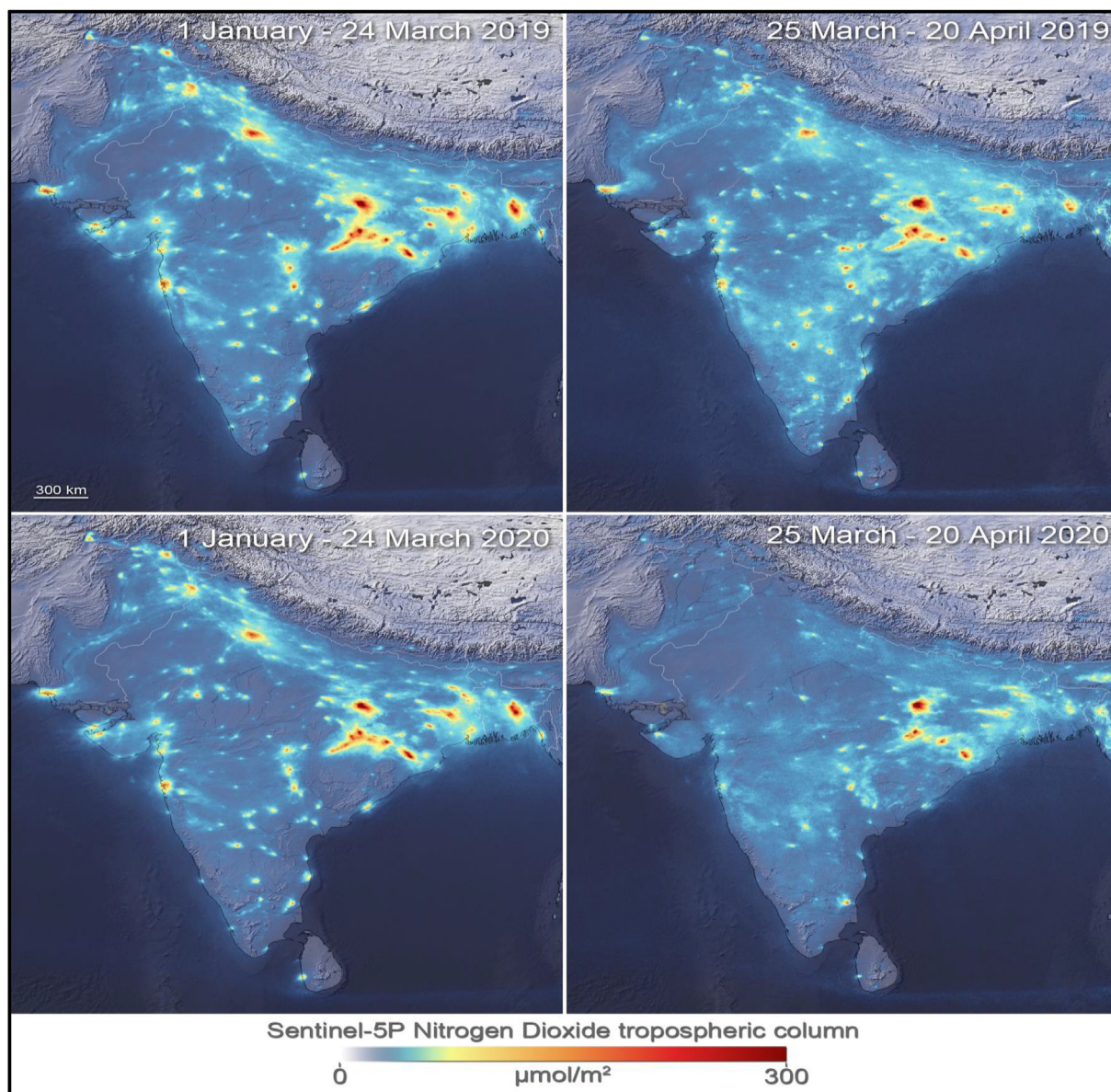


Fig. 4. Satellite images of NO_2 levels in Indian atmosphere (ESA, 2020).

It is a time for policy makers and government to plan strategies to come to normal life in post-Covid era. From previous discussion it is clear that a one-month lockdown has done such a miraculous change in environmental condition which was beyond thinking for us just couple of months back. This is also true that lockdown conditions can not be imposed forever, industries cannot be shut down for infinite time or vehicular movement cannot be restricted for much longer time but the patterns can be changed and a more responsible behaviour can be adopted. It is a known fact that anthropogenic activities are the major cause behind degraded environmental condition and disturbed ecology, but in last two months, it has become evident that still it can be restored significantly if sufficient mitigative measure and strategic government policies are planned before removing all the restrictions.

4. Conclusion

Covid-19 which originated in Wuhan somewhere three months back has now taken refuge in host bodies in 210 countries around the globe infecting 1,968,893 people and 123,783 deaths as on 14th April 2020. On same day, India has also reported to have more than 10,000 positive

cases with 350+ death toll. The condition is still uncontrolled and with no proven cure for the virus. Locking down in homes and social distancing is the only preventive step that the entire country is following. But as the human activities are restricted in most of the areas, the natural environment of country has started healing itself. Factories, transport, vehicles and aviation have all ground to a halt. Carbon emissions have decreased and the quality of air has seen an unprecedented improvement. It is remarkable to see a reduction of 85.1% in $\text{PM}_{2.5}$ concentration in one of the India's most polluted city (Ghaziabad), as compared to the concentration just three months back. The other parameters like PM_{10} , NO_2 , and CO has also reduced distinctly which is the result of restricted human activities and mechanical movements. Satellite images of Indian atmosphere also reflects the same trend of reduction in air pollution after COVID-19 outbreak. The Air quality index (AQI) in all the states of India are now in two figures (indicating moderately good quality of air) after this lockdown. Not only air but the rivers of India like Ganga, Yamuna, and Cauvery etc. have become clean and clear and marine life is visible. After reviewing various reports as cited earlier, it can be summarised that undoubtedly COVID-19 has brought a fearful devastating scourge for human being

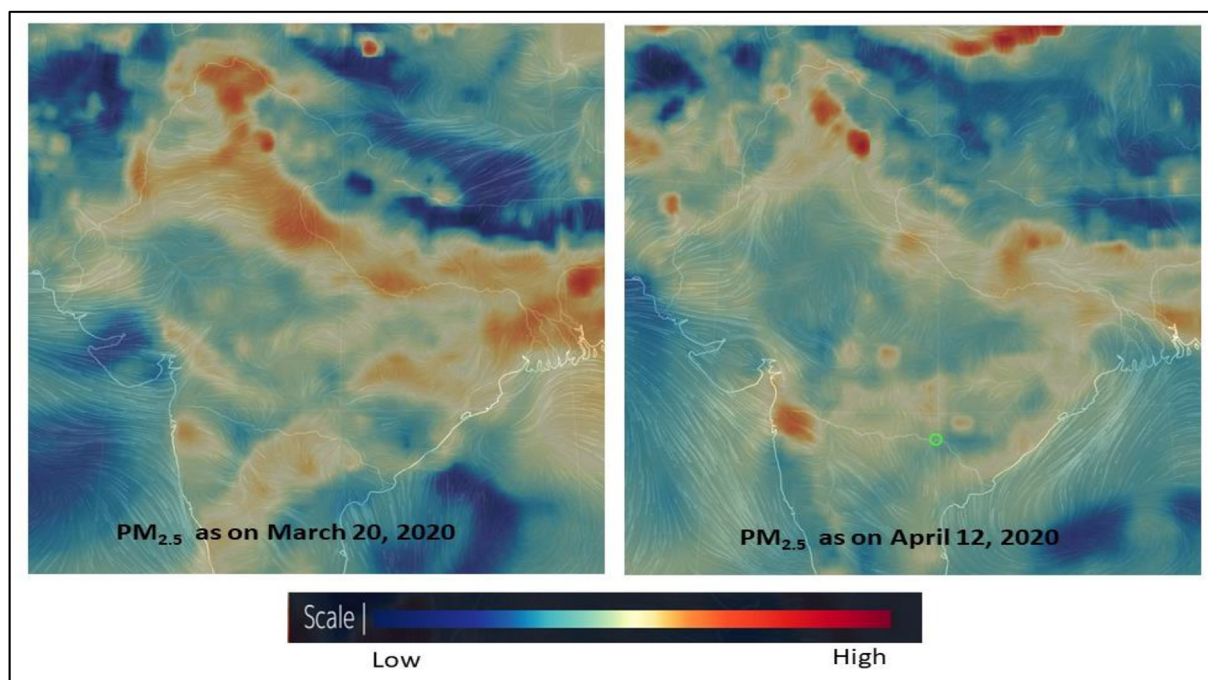


Fig. 5. Levels of $PM_{2.5}$ in Indian atmosphere (Becarrio, 2020a).

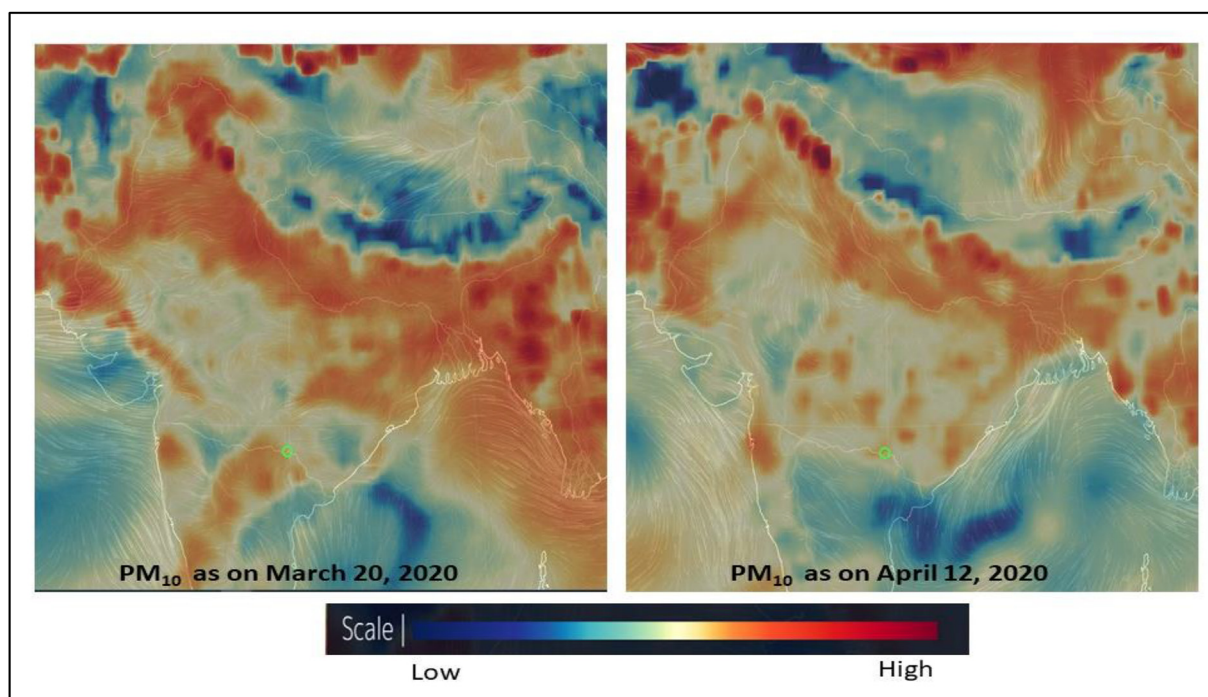


Fig. 6. Levels of PM_{10} in Indian atmosphere (Becarrio, 2020b).

but it has emerged as a blessing for natural environment providing it a “recovery time”. We have also learnt that the environmental degradation caused by humans is not totally irreversible. In a period of just 1–2 months, “recovery of nature” is being witnessed by everyone. This is a signal for us to understand and react. Government and Policy makers should take necessary steps so that this healing process does not become a temporary thing. The research focusses on the changes in air quality during the lockdown period. There is a need for rigorous study on the effect of implementation of such short term lockdown as an alternative measure for pollution reduction and its effect on economy. This study may also be used as a reference document to analyse post covid

condition as well to analyse effect of reduced pollution on health data of sensitive receptors. At present when entire globe is struggling to frame proper strategies to combat Covid-19, the early lockdown implemented has shown an absolute way towards restoring ecosystem and environment.

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Table 4
Weekly AQI data (before and during lockdown period) (NAQI- CPCB, 2020).

Sl. No	State Name	Station Name	AQI before lockdown	AQI after declaration of lockdown			
			14 January' 2020	24 March' 2020	31 March' 2020	7 April' 2020	14 April' 2020
1	Andhra Pradesh	Anand Kala Kshetram, Rajamahendravaram – APPCB	216	62	69	29	37
2	Bihar	Muzaffarpur Collectorate, Muzaffarpur - BSPCB	367	266	134	65	84
3	Chandigarh	Sector-25, Chandigarh – CPCB	75	35	38	41	45
4	Delhi	IHBAS, Dilshad Garden, Delhi - CPCB	301	99	24	37	53
5	Haryana	Sector- 16A, Faridabad – HSPCB	315	151	121	121	78
6	Karnataka	Peenya, Bengaluru – CPCB	143	105	50	57	63
7	Maharashtra	Chhatrapati Shivaji Intl. Airport (T2), Mumbai – MPCB	122	94	68	55	67
8	Punjab	Model Town, Patiala – PPCB	106	49	26	43	51
9	Tamil Nadu	Alandur Bus Depot, Chennai – CPCB	172	42	40	29	27
10	Telangana	ICRISAT Patancheru, Hyderabad - TSPCB	130	64	64	47	77

Table 5
Water quality data at monitoring stations at Kanpur as on 28th March 2020 (SANDRP, 2020).

Location of monitoring station	DO (mg/l)	BOD (mg/l)	pH	NH ₃ (mg/l)	COD (mg/l)
Upstream of Ganga Barrage	8.0	2.1	7.9	0.49	< 9.0
Downstream of Ganga Barrage	7.9	1.21	7.91	1.1	< 9.0
Shuklagunj	8.51	2.1	7.68	0.79	< 9.0

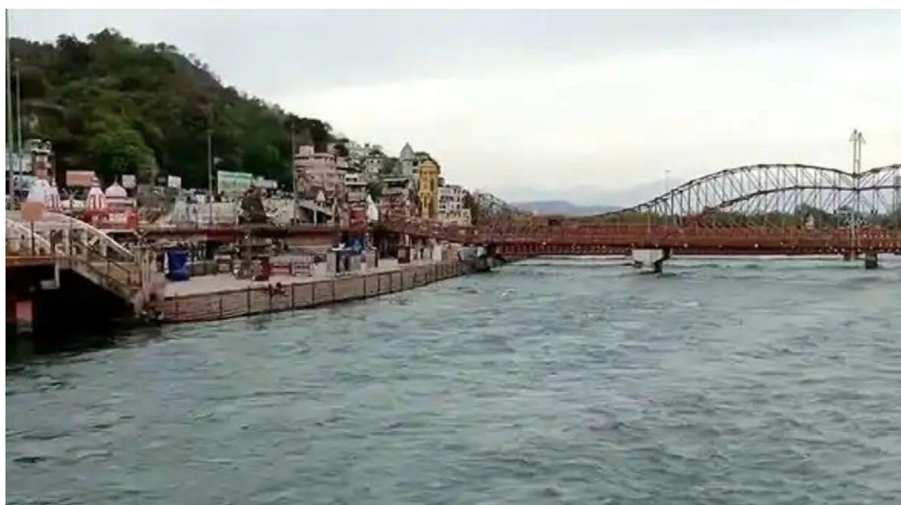


Fig. 7. Clean water of River Ganga at Haridwar as on 13th April 2020 (News18 Buzz, 2020).

Credit author statement

Snehal Lokhandwala: Conceptualization, Validity, Resources, Writing (Original Draft), Writing (Review and editing), Investigation.
Pratibha Gautam: Conceptualization, Validity, Formal Analysis, Data Curation, Writing (Original Draft), Writing (Review and editing).

Declaration of competing interest

None.

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